NC3A Simulation Support for NATO Exercise Clean Hunter 2001

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Abstract

This paper discusses modeling and simulation methods employed to support the Conventional Counter-Force missions (CCF) and Passive Defence missions during the Supreme Headquarters Allied Powers Europe (SHAPE) sponsored exercise Clean Hunter (18 – 29 June 2001), at the AIRNORTH Command Centre located at Ruppertsweiler, Germany. NC3A and member nations of the Coalition Aerial Surveillance and Reconnaissance (CAESAR) project contributed simulated ground vehicle movements (including Transporter-Erector-Launcher (TEL) battery and infrastructure), interoperable Airborne Ground Surveillance (AGS) platform and sensor simulations, and exploitation workstations in support of the Theatre Missile Defense portion of the exercise. During this exercise, CAESAR data from seven simulated Moving Target Indicator (MTI) and Synthetic Aperture Radar (SAR) sensors, developed at a single site, was disseminated to Combined Air Operation Centers (CAOC) in Germany and the UK and to the Centre de Coordination des Operations Aeriennes (CCOA) in France.

This paper discusses the nature of the simulation environment supplied by NC3A for exercise Clean Hunter 2001 including the scenario generation, sensor system models and the communications required to link sites in five nations. Discussion will also include future plans for CAESAR simulation work including distributed experiments using the Combined Federated Battle Lab Network (CFBLNet), advanced scenario generation using semi-automated forces (SAF) technology and High Level Architecture (HLA).

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Introduction

Airborne Ground Surveillance (AGS) operations present a unique challenge for real-time simulation. The area of coverage is large, corps- or theatre-sized, and the simulated sensor systems require highly detailed terrain, features and battlefield movement at the individual entity level. The radar-based sensors discussed here employ Ground Moving Target Indication (GMTI) and Synthetic Aperture Radar (SAR) modes capable of detecting individual vehicle motions and imaging them. Further, interoperable exploitation workstations generate tracks from the combined (and often overlapping) sensor coverage and provide the analyst with a detailed picture of the battlespace. In order to provide robust training, the simulation must accurately reflect the operational context, in this case, the employment of Theatre Ballistic Missiles (TBM) during a large NATO exercise.

The full complement of Coalition Aerial Surveillance and Reconnaissance (CAESAR) project was present at Clean Hunter 2001, including sensor simulations representing ASTOR (UK), CRESO (IT), Global Hawk (US), HORIZON (FR), Joint STARS (US), RADARSAT II (CA), and U2 (US). Additional exploitation systems included associated ground stations for each of the sensor simulations and IIES (GE), JSWS (US), Matrex (US), MTIX (US) and MTOC (NO) (Table 1).

NATO C3 Agency

The NATO C3 Agency, which is overseen by the NATO C3 Organization, was established on 1 July 1996 to provide this capability. Formation of the Agency was achieved by the amalgamation of the former SHAPE Technical Centre and the NATO Communications and Information Systems Agency. The NC3A operates under the policy direction of the NATO C3 Board.

The NATO Consultation, Command and Control Agency (NC3A) is located in two facilities: one in The Hague, Netherlands and one in Brussels, Belgium. The mission of the NC3A is defined in the charter of the NATO C3 Organization (NC3O)[1].

The mission of the NC3A is to:

- Perform central planning, systems integration, design, systems engineering, technical support and configuration control for NATO C3 systems and installations.
- Provide scientific and technical advice and support to the Strategic Commands and other customers on matters pertaining to operations research, surveillance, air command and control including theatre missile defence, electronic warfare and airborne early warning and control, and communications and information systems, including technical support for exercises and for unforeseen operations assigned to the NATO Military Authorities (NMA) by the North Atlantic Council (NAC)/Defence Planning Committee (DPC).

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[1] NC3A website (http://www.nc3a.nato.int/pages/frameset_org.html)

- Perform technical policy and standardization work in support of the NATO C3 Board and its substructure towards the development and maintenance of the NATO Interoperability Framework (NIF).
- Procure and implement projects assigned to it.

Command and Control Concepts and Architecture Branch

The organization of the NC3A consists of a General Management office, Executive Staff and five divisions. The work discussed here was performed under the Command & Control Systems Division, Command and Control Concepts and Architecture Branch (CCB)[2], which serves as the NATO Centre of Excellence for Theatre Missile Defense (TMD) Battle Management Command and Control and Aerospace Ground Surveillance and Reconnaissance.

The Branch consists of eight scientists and three scientific-support staff, augmented at various times by technical experts supplied by nations in order to support the work of the Branch. On behalf of SHAPE, the CCB Branch is responsible for a number of activities, including:

- The definition of requirements for emerging NATO airborne ground surveillance and reconnaissance (AGSR) capabilities
- Technical management of the Coalition Aerial Surveillance and Reconnaissance (CAESAR) activity
- The definition of NATO's Theatre Missile Defence Battle Management Command Control and Communications requirements.

In addition, on behalf of the Conference of National Armaments Directors, the Branch is providing support to the NATO Active Layered Theatre Ballistic Missile Feasibility Studies.

The Clean Hunter 2001 exercise provided an opportunity for the Branch to exercise two of the three pillars of Theatre Missile Defence, namely, Passive Defence using the Shared Early Warning (SEW) system, and Conventional Counter-Force Operations (CCFO) utilizing the interoperable CAESAR AGS systems. Battle Management, Command, Control, Communications and Intelligence (BMC3I) serves as the linkage. The third pillar, Active Defence, was not employed in this exercise.

The role of the Branch in the exercise was to provide the hardware, software and communications capability required to enable detailed simulation of TMD activity of suitable fidelity such that the training objectives of the Joint Theatre Missile Defence Cell (JTMDC) could be achieved.

NATO Airborne Ground Surveillance (AGS) Capability Testbed (NACT)

In November of 1995 the Council of National Armaments Directors (CNAD) decided that NATO should acquire an AGS capability based on NATO-owned and -operated core capabilities

[2] Branch website http://www.nc3a.nato.int/pages/ccsdiv/ccb/ccb_main.htm

supplemented by interoperable national assets. The NACT was then established with the support of NC3A, SHAPE and six nations and provides the NATO nations with a unique international testbed for research and development of interoperable AGS systems in support of NATO AGS requirements.

The NACT consists of NATO and nationally supplied hardware and software that allows systems to be interconnected for the purposes of enhancing development efforts, performing experiments, providing demonstrations and participating in exercises. The NACT consists of two local area networks (LANs), a simulation LAN using the Distributed Interaction Simulation (DIS) protocol and an exploitation LAN where data is passed in NATO EX and Link-16 message formats (Figure 1). For Clean Hunter, the NACT was relocated to sites in five nations and connected through dual ISDN lines. See Figure 2 and Table 1.

Achieving Interoperability

The key element in achieving interoperability across this diverse collection of AGS systems is the use of the NATO EX message format[3]. Acting as the precursor to the Common Ground Moving Target Indicator (CGMTI) message[4], NATO EX consists of a header and multiple segments, including MTI, HORIZON FTI, ESM, Imagery (including Spot SAR, Swath SAR, EO and IR), CRESO Activity Indicators, Joint STARS FTI, group tracks and freetext messages. By reformatting data at the ground station, information from all of the sensor and exploitation systems can be shared without considerations of proprietary datalink issues.

CAESAR

The CAESAR project initiated as a seven-nation project in January 2001. Member nations include Canada, France, Germany, Italy, Norway, the United Kingdom, and the United States.

A true coalition effort, a central objective of the project is to develop the Operational Concepts (CONOPS), Tactics Techniques and Procedures (TTPs), and Technology that will enhance the interoperability of existing and planned Coalition Ground Surveillance assets. Based on simulated experiments and live-fly exercises, the project provides a vehicle to develop, demonstrate, evaluate, and transition into existing hardware the ability to:

- Disseminate Ground Moving Target Indicator (GMTI) and Synthetic Aperture Radar (SAR) data and exploitation products from multiple platforms and exploitation capabilities in a common format
- Provide enhanced exploitation of GMTI and SAR data for improved correlation, location accuracy, tracking continuity, and tracking accuracy
- Archive, search, and retrieve SAR and GMTI data using a distributed database architecture
- Produce data or displays to support the development of a Common

[3] NC3A Technical Note 732, Formats for the Representation of Alliance Ground Surveillance (AGS) Pre-Exploitation Data Types, October 1998. NATO Unclassified.
[4] See also STANAG 4607 (CGMTI) draft version 1.01d5a, 27 April 2001.

Operational Ground Picture and/or Joint Tactical Ground Picture
- Assist in evaluating the effectiveness of multiple assets in supporting Requests for Information (RFI) and the impacts on platform Mission Tasking and Planning
- Migrate GMTI and SAR exploitation to an Internet Browser based, hardware-independent solution
- Provide more accurate representations of simulated ground movement to support development and training.

In addition, the project provides the context for developing, implementing, evaluating, and refining the operational processes required to effectively task, plan, operate, and exploit Coalition Ground Surveillance Assets to support Intelligence Preparation of the Battlefield (IPB), Indications & Warning (I&W), Situation Awareness (SA), and Targeting.

NATO Exercise Clean Hunter 2001

Clean Hunter, an annual NATO live-fly exercise, was conducted from 18 - 29 June 2001, and took place in Allied Command Europe Northern Region and Northern France, with live-flying during the periods 18-22 and 25-29 June 2001. US European Command supported the exercise, which was conducted by Headquarters Allied Air Forces North (AIRNORTH) through its Combined Air Operations Centres (CAOC). Clean Hunter 2001 involved air forces from Belgium, Canada, the Czech Republic, Denmark, Germany, Greece, Italy, the Netherlands, Norway, Poland, Portugal, Turkey, the United Kingdom and the United States. France joined the exercise as part of the normal training relations that have been established with its Allies.

Exercise Objectives

Clean Hunter 2001 was designed to promote training opportunities for all participating units to maximize interaction between opposing forces and to exercise AIRNORTH and its subordinate CAOCs in the planning and conduct of major coordinated live air operations. NC3A simulation support for this exercise was limited to the TMD portion of the exercise. The transporter-erector-launcher (TEL) units operated in the two live-fly areas of Baumholder and Diepholz, Germany.

CAESAR Objectives

The purpose of the CAESAR initiative during the exercise was to evaluate the benefits of displaying and exploiting Ground Moving Target Indicator (GMTI) and Synthetic Aperture Radar (SAR) imagery from multiple sensor platforms to increase the air and ground commanders' Situation Awareness. CAESAR identified a number of goals:

- Examine the way in which data from the assets is used and disseminated

- Examine the way the exploitation assets are integrated into the Joint Theatre Missile Defence Cell (JTMDC) and Intel Cell

- Examine the way in which AIRNORTH allocates the CAESAR assets to support the overall goals of the exercise

- Develop and refine the operational procedures for use of multiple ISR assets to support the Intel Cell and JTMDC

- Demonstrate how sharing and exploiting GMTI and SAR data produced by multiple AGS&R sensors can support overall SA, Indications and Warning (I&W) and Counter-Force Operations (CFO).

TMD Scenario

The scenario featured two coalitions: The Inner (CAOC 2 and CCOA), and the Outer (CAOCs 1, 3, 4, and 9) each with Ground, Naval and Air Headquarters (Figure 3). While the live-fly portion of the exercise involved constant combat over a two-week period, the TMD portion of the exercise provided two variations of the scenario. During week one the Inner Coalition played the Baumholder (GE) scenario and CAOC 2 and CCOA commanded and controlled the Conventional Counter-Force (CCF) assets allocated to them. During the second week of the exercise the Outer Coalition played the Diepholz (GE) scenario and CAOCs 4 and 9 conducted the CCF operations.

TMD in CLEAN HUNTER 2001

The objective of the TMD segment of Clean Hunter was to provide a realistic Tactical Ballistic Missile (TBM) threat. The Exercise mission was to protect NATO forces from TBM attack through CCF operations against threat coalition(s) to ensure that threat TBM infrastructure and support systems could be destroyed prior to TBM launch.

The A-2 (Intel) organisation within AIRNORTH provided detailed site surveys and movement plans for TEL batteries and the associated infrastructure units (resupply, HQ, transload units, etc.) consistent with the threat CONOPS. These planned movements were matched with actual vehicles (surrogate TELs), which allowed engagement from live-fly CCF assets.

The TBM launches were synchronized with the US Joint National Test Center in Colorado Springs, which provided simulated warning information from US sources. This data was transmitted to the NATO inject point in the UK which then fed the NC3A Shared Early Warning (SEW) system which forwarded launch and impact warnings throughout NATO using the secure wide area network (WAN) CRONOS and the Integrated Command and Control (ICC) network. A US-only element was also operated by the 32nd Air Operations Squadron (AOS) as part of the Joint Theatre Missile Defence Cell (JTMDC).

JTMDC Description

To support the TMD mission, the JTMDC was stood up. The JTMDC was the hub of Battle Management/ Command, Control, Communications, Computers and Intelligence (BMC4I) capabilities required to coordinate Counter-Force (CF) and Passive Defence (PD) operations, and to integrate these elements into overall combat operations. (Figures 4 and 5). Together, the JTMDC and the BMC4I elements were responsible for:

- Maintaining the capability to support intelligence and operations for TMD planning and execution
- Supporting TMD operations with joint/combined forces

- Supporting tasking to appropriate multinational forces.

JTMDC Concept

The JTMDC was organized as a 'centralized' target development process. Target development was the responsibility of the JTMDC (rather than the CAOCs) and the new structure was implemented to maximize the available assets and to facilitate the flow of information to the JTMDC Chief. Information produced by the operators at the first-tier exploitation workstations could be rapidly disseminated to the second-tier analysts (ISR Coordination) for target development. The physical layout of the room (Figure 5) was based on the small theatre model to permit maximum visibility of the large screen by all members of the JTMDC team and over-the-shoulder viewing of the workstations from the second and third tiers. Operators and analysts were in close physical proximity to each other and to the JTMDC Chief.

AGS Exploitation in the JTMDC

AIRNORTH was responsible for developing targets and determining surveillance priorities and had the flexibility to deploy multiple assets over a target. Multiple sensor data was subsequently exploited by the operators at each exploitation workstation, as directed by the Intelligence Surveillance and Reconnaissance (ISR) Coordinator in the JTMDC.

Tasks for the operators in the JTMDC and Current Ops cell focussed on developing Situation Awareness (SA) to nominate Time Sensitive Targets (TST)[5]- infrastructure to their cell chiefs based on GMTI data, launch messages and IPB[6].

JTMD operators used their exploitation workstations to display and disseminate information. The exploitation tools available to the operators included automatic trackers, historical replay of GMTI and SAR imagery, and launch warning data from NC3A's SEW and the US Attack and Launch Early Reporting to Theater (ALERT) systems.

Through the use of these tools, operators could locate fixed or mobile vehicles, characterize movement and propose targets. In addition, operators could initiate some tracking, which allowed near-real-time (NRT) target updates of vehicle locations. Based on the Area of Interest (AOI), specific mission tasking and operational location, each operator worked to fulfil the local requirements. Operators had the ability to select a mix of tools and sensor data from both local and distributed sources.

Simulation of TMD Operations

While Clean Hunter 2001 was a large live-fly exercise it was necessary to simulate the TMD portion because there were no ISR assets scheduled. In support of the TMD mission, simulation was used to represent missile launches, TBM vehicle operation and general battlefield traffic movement.

[5] Time Sensitive Targets (TST) can be engaged within 30 minutes, Time Critical Targets (TCT) less than 5 minutes.
[6] CAESAR Evaluation Team Lessons Learned Clean Hunter 2001, ACD-CAESAR-06, NC3A, 30 August 2001. NATO Restricted.

- The Missile Defence and Space Tool (MDST) was used to input missile launch information into the early warning systems and represented ALERT, Tactical data and reporting (TACDAR) and the Space-Based Infra-Red System (SBIRS).
- The Integrated Target Environment Simulation Tool (ITEST) was used to simulate ground vehicle movement.
- The various CAESAR sensor simulations were used to generate target detections for use by the exploitation workstations.

AGS Simulation Requirements

AGS is a demanding simulation domain in that some assets operating at higher altitudes (ASTOR, Joint STARS, RADARSAT II, U2) cover corps areas with real-time sensors capable of detecting individual vehicles and imaging them. In such an area of interest, the number of objects that pass the Doppler detection threshold for a typical GMTI sensor can easily be numbered in the tens of thousands[7]. Further, advances in GMTI exploitation (primarily tracking algorithms supporting traffic flow analysis) now require that the vehicle motions be realistic but the movements that are being performed be operationally realistic.

Fortunately, Clean Hunter TMD operations were limited to the relatively small geographic areas of the Baumholder and Diepholz live-fly areas and for the exercise the number of entities actively moving was kept to a manageable limit of less than 5000. This number was determined by the limitations to the commercial-off-the-shelf (COTS) truth display used to monitor simulation status.

Ground Movement

The accurate representation of ground movers is essential for the effective stimulation of AGS sensor simulations and for the advanced AGS exploitation systems present in the CAESAR project. TEL batteries have to follow an intricate sequence of movements (transload site, hide, fire, hide, reload, fire, hide, transload/overnight). Supply units must move at prescribed times to specific sites and headquarter units relocate as part of operational security (OPSEC). Key objectives of the exercises were the location and attack of TBM infrastructure targets: Transload, Forward Operating Locations (FOL), Forward Operating Bases (FOB) and Headquarter (HQ) sites. The simulation of these facilities was represented with stationary vehicles that could be imaged with the various SAR sensors.

On top of the simulated military operations, background traffic must be represented, either 'other' military traffic or that of civilians. During the first week of the exercise there was an exercise element 'Schwartze Himmel' that contained large amounts of refugee traffic flowing through the exercise area.

The first week (Baumholder) employed the traffic-generation technique used in previous exercises, which re-locates the entity at a starting point along a new route when it has reached the end of its

[7] Given the proper scenario the low and medium altitude systems such as CRESO, HORIZON, and Predator can observe large numbers of objects.

route. This allows for tight control of the number of entities moving about the scenario region. It used groups of varying numbers of vehicles with the same spacing and speed travelling together to form convoys. The tool also produced an evenly distributed set of vehicles on all routes at the beginning of the scenario run.

The downside was that it re-used the entity ID, causing 'teleportation' from route end to its new start point on the next route. This technique produced few vehicles that were stopped, an artefact that is important considering the role SAR played in target classification during the exercise. Also, speed and route variations were made on a vehicle group basis and not on an individual vehicle basis.

During the second week of the exercise an alternative background approach was employed which started new vehicles when the end of a route was reached. This removed the re-use of entity IDs as well as created 'parking lots' at the beginning and end of the routes. It also prescribed individualized movement characteristics for each vehicle.

The ‘parking lots’ of vehicles mentioned above were sometimes detected by operators as militarily significant sites. Also, no convoy movement was simulated in the background traffic so only military convoys had this movement signature. In addition, the tool did not produce an evenly distributed set of vehicles along major routes at start-up, so route start points were obvious to operators. On a technical note, the increased number of entities required to support this scheme was sometimes taxing on the DIS monitoring tools and simulators running at the time.

Simulation Bandwidth Usage

The data networks deployed by NC3A utilized dual 64kbps ISDN lines. The general observation is that 128kbps lines are more than adequate for dissemination of MTI data but SAR imagery creates a significant load on communications lines requiring a buffering scheme to handle large imagery products. A sample of one day of bandwidth utilization is provided in Figure 6.

ITEST

ITEST is a scripted scenario generator that is capable of generating up to 30,000 entities on a Sun Ultra 60 workstation.[8] Using the detailed movement plans provided by AIRNORTH, scripts were built that moved the TEL batteries as well as the associated infrastructure units (Figure 7). A key element of simulation of ground movers is the representation of terrain and the road network. The movement plan supplied gave time of departure and arrival for each of these moves. In the case of secondary or minor roads that did not appear in the cartographic network database representation of roads, manual entry of road segments were input using 1:50000 scale TLM map underlays. In terms of matching the movement plans this map underlay capability was essential.

Features for Imaging Sensors

[8] Trident Systems ITEST tool, originally specified to simulate up to 5000 entities, is no longer in development.

Target development hinged on the use of SAR imagery to provide an element of target classification; target identification was performed by tactical reconnaissance aircraft or eyes-on-target from tactical aircraft or Special Operations Forces (SOF). GMTI by itself does not currently provide identification capability[9]. In order to simulate SAR modes the sensor models (ASTOR, Global Hawk, and VSTARS) combine digital terrain elevation data (DTED), the road network data, and cultural features data (Vector Map or Digital Features Analysis Database (DFAD). Generally the systems use the 100-meter Level 1 data for this application.

The Way Ahead

The C2 Concepts and Architecture Branch is dedicated to expanding the current simulation technology within the NACT. A number of efforts have been identified and this section briefly describes our plans for the near term.

Semi-Automated Forces

The nature of the TBM threat lends itself to scripted simulation. TEL battery and infrastructure movements must be planned well in advance with launch and hide sites pre-surveyed to accommodate the large, cumbersome vehicles. Modern maneuver warfare as a general rule is dynamic and for NC3A and the CAESAR project to support Article V high-intensity combat an alternative to scripted scenario generation is required. In November of 2001 NC3A received the OneSAF simulation[10], a highly detailed code that contains automated behaviors based on military doctrine. The complexity of OneSAF requires multiple processors in order to support AGS operations so a cluster PC has been assembled in the NACT to support battalion-level combat simulation.

Strong Resolve

The CAESAR teamjust returned from Norway where it participated in Strong Resolve 2002. This large live exercise did not include simulation but MTI and SAR data from actual HORIZON, RADARSAT I, and Joint STARS platforms were successfully shared by the entire CAESAR suite of exploitation workstations. During non-flying times OneSAF was operated in small scenarios representative of the current situation.

Distributed Simulation

The logistics of transplanting the NACT equipment entail a substantial a cost for the Branch and research into performing distributed simulation AGS experiments using the Combined Federated Battlelab Network (CFBLNet) is underway. A network of high-capacity secure communications lines, CFBLNet may provide a more cost-effective way of conducting experiments. It is not used for operational applications.

High Level Architecture

In November 2002 the Branch will participate in NATO exercise Cannon Cloud 2002 (CC02), again supporting the TMD portion for AIRNORTH. CC02 is a large, multi-corps computer

[9] High Range Resolution (HRR) mode will be available in the VSTARS simulation in the near future. This can feed 1-D Automatic Target Recognition (ATR) algorithms.

[10] Operational Testbed (OTB) International Release, version 1.0

aided exercise (CAX) featuring the aggregate Joint Theater Level Simulation (JTLS) and the Extended Air Defense Simulation (EADSIM). These codes are HLA and initial work has begun to link the NC3A SEW software to JTLS and EADSIM. It is anticipated that this work will expand to ultimately link the other labs within the Division into an HLA federate.

Synthetic Environment

Each of the AGS systems described here, be it a sensor simulation or an exploitation workstation, is a powerful geographic information systems (GIS) which requires accurate and consistent data to operate and, perhaps more importantly, to interoperate. Digital mapping data is provided to the Agency through our SHAPE sponsor. This work has recently been expanded to include the maintenance of synthetic exercise databases and discussions are under way to consider key environmental databases that are not within the scope of the current Programme of Work.

Within the Branch, investigations have begun into the feasibility of using the Synthetic Environment Data Repository Interchange Specification (SEDRIS) as a means of providing a method for CAESAR participants to access a variety of GIS databases, including atmospheric information. Recently NATO Land Group 8 emphasized the value of SEDRIS (as well as HLA) in the role of training simulation interoperability[11].

A drawback to the use of OneSAF is the difficulty and/or expense of creating terrain databases (compact terrain databases (ctdb)). SEDRIS provides a capability to build ctdb files using SEDRIS Transmittal Format (STF). This could provide an efficient way to generate OneSAF databases as well as convert to other formats for use with the NACT.

JDEP

The Joint Distributed Engineering Plant (JDEP) concept was briefed to NC3A in December 2001. JDEP is designed to improve the interoperability of weapon systems and platforms through rigorous testing and evaluation in a replicated battlefield environment. The JDEP program was established as a Department of Defense (DoD)-wide effort to link existing service and joint combat system engineering and test sites (including design activities, software support activities, test and evaluation facilities, training commands, and operational units)[12]. This approach to interoperability testing fits well with NC3A and Branch goals.

JDEP Track 1 began in the 3rd Quarter 2001 and is a proof of concept for Joint Theater Air Missile Defense (JTAMD). Track 2, JTAMD expansion, began in 2002 with Track 3 concurrently expanding to other mission areas.[13] We hope that NC3A in general, and the AGS capabilities in particular, can contribute to the JDEP project.

[11] Minutes from Mr. Gene Weihagen, Chair, NATO Land Group 8 on Training Simulation Interoperability, 31 January 2002.

[12] Defence Planning Guide Update FY 2002-2007, Guidance, p. 112

[13] Dr. V. Garber, National Defense Industrial Association brief 23 October 2001, p. 16, http://www.dtic.mil/ndia/2001systems/

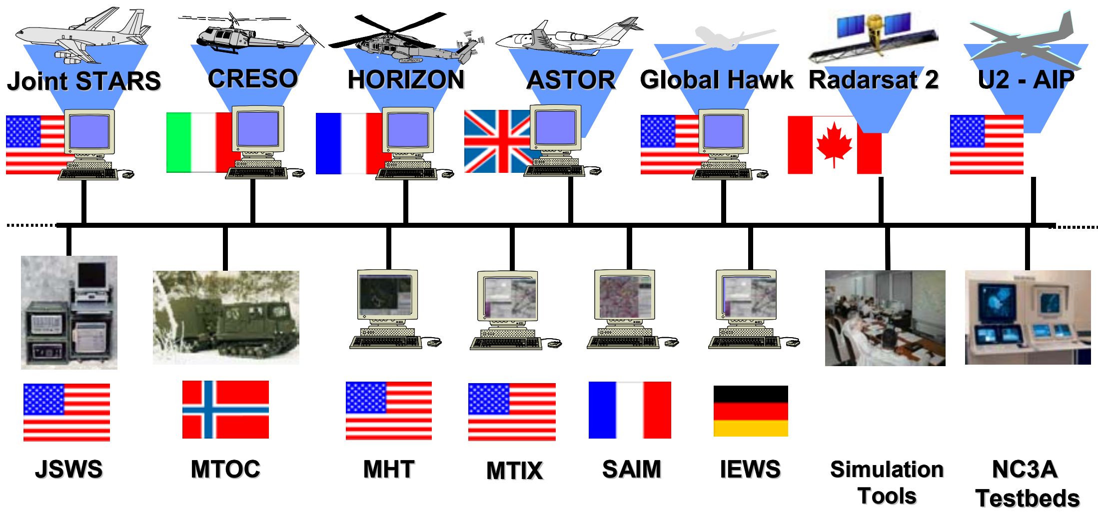


Figure 1: NATO Airborne Ground Surveillance (AGS) Capability Testbed (NACT)

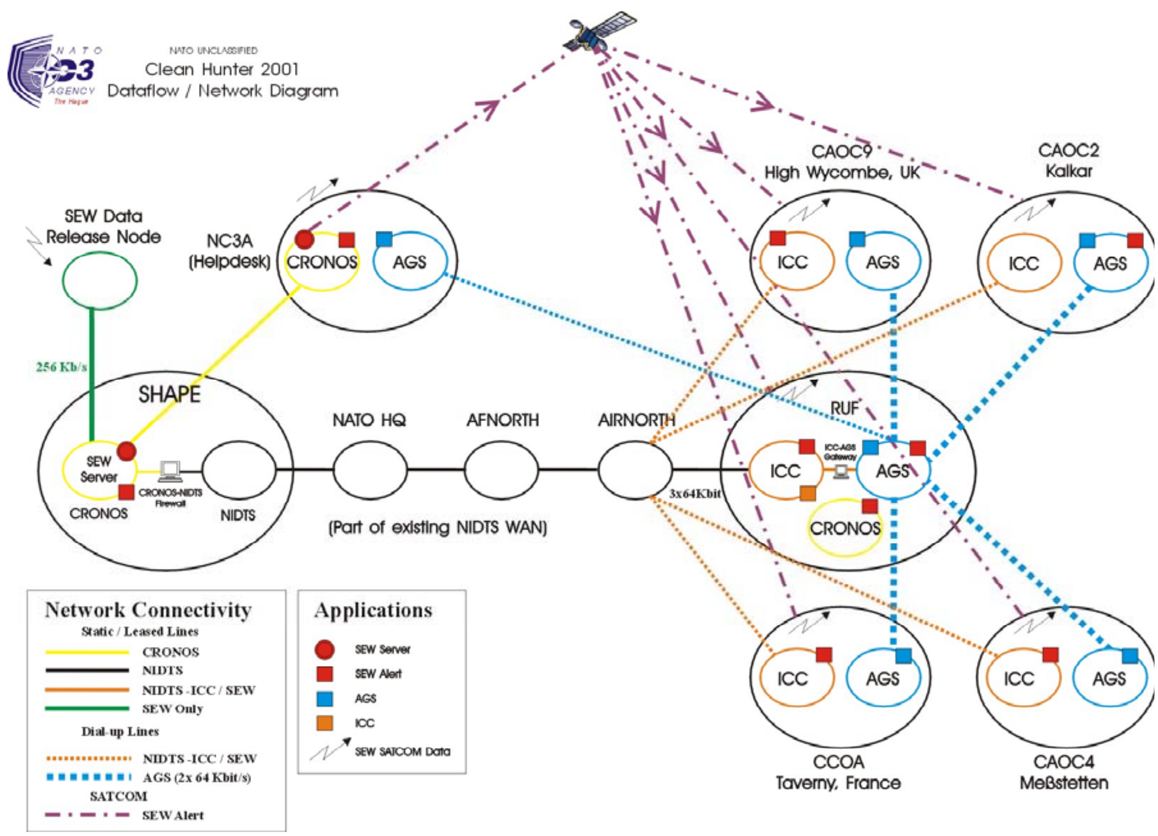


Figure 2: CAESAR Network Topology

Testbed Element	Capabilities	Location
(CA) Spaced Based Radar GMTI	MTI Sensor	AIRNORTH
(FR) HORIZON	Helicopter-based MTI sensor and workstation	AIRNORTH
(FR) SAIM	Exploitation workstation	CCOA
(GE) IIES	Exploitation workstation	CAOC 4
(IT) CRESO	Helicopter-based MTI sensor and workstation	AIRNORTH
(NO) MTOC	Exploitation workstation	CAOC 2
(UK) ASTOR	Aircraft-based MTI and SAR sensor	AIRNORTH
(UK) ASTOR GS	Exploitation workstation	CAOC 9
(US) CREWS	Exploitation workstation	AIRNORTH
(US) Global Hawk	UAV-based MTI and SAR sensor	AIRNORTH
(US) JSTARS	Aircraft-based MTI and SAR sensor	AIRNORTH
(US) JSWS	Exploitation workstation	CAOC 4
(US) MATREX	Exploitation workstation	CAOC 4
(US) MTIX	Exploitation workstation	AIRNORTH
(US) U2	Aircraft-based MTI and SAR sensor	AIRNORTH

Table 1: Distribution of CAESAR AGS simulations and exploitation workstations for Clean Hunter 2001

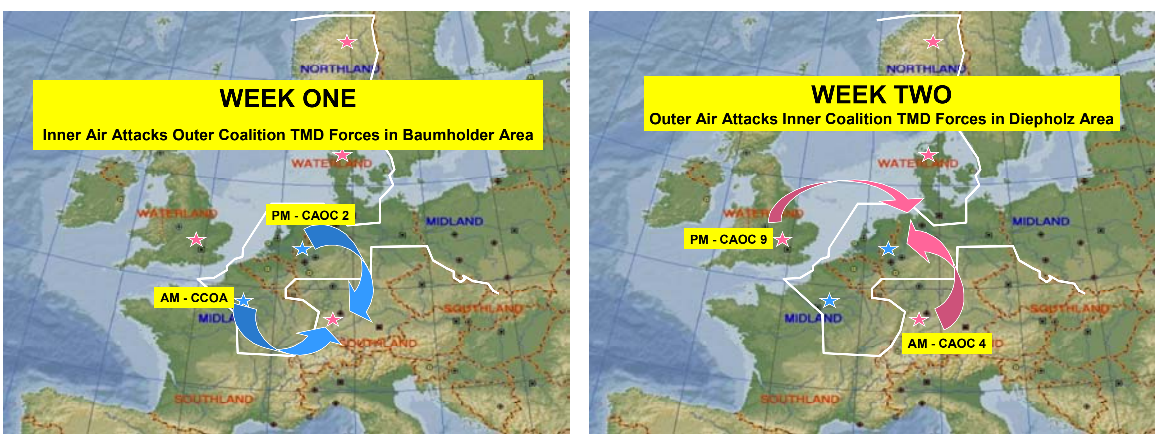


Figure 3: Clean Hunter 2001 Scenario

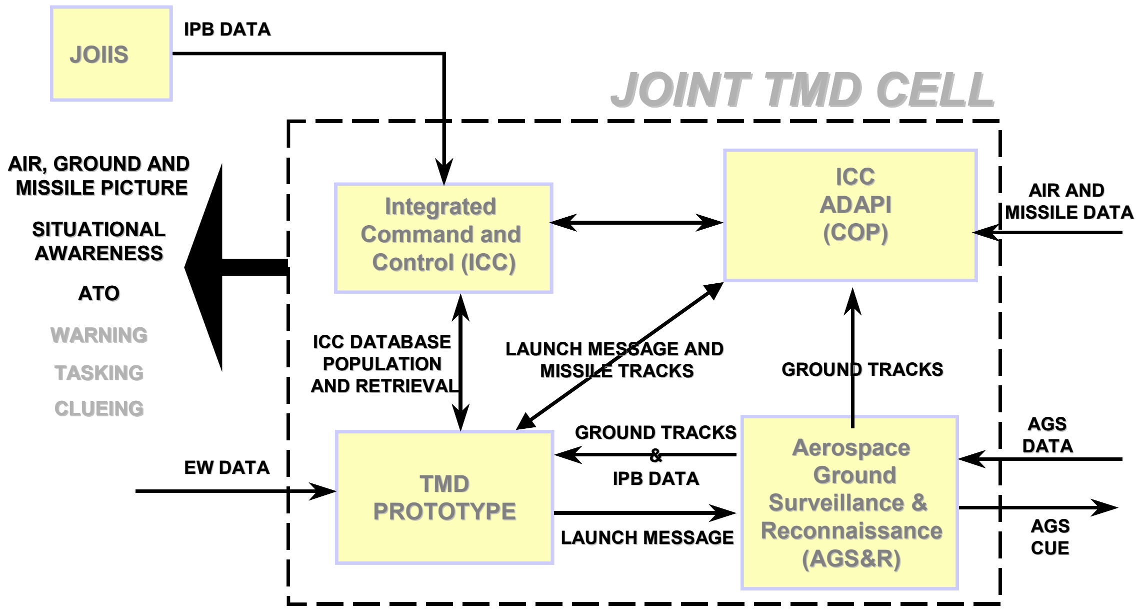


Figure 4: System Integration for NATO TMD C2

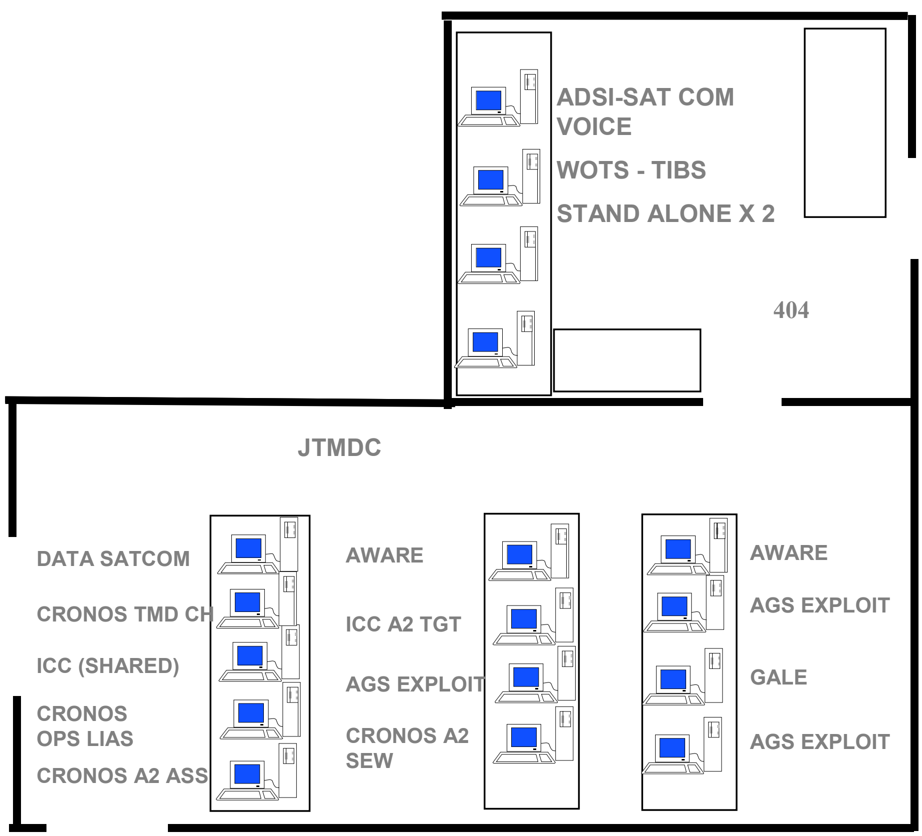
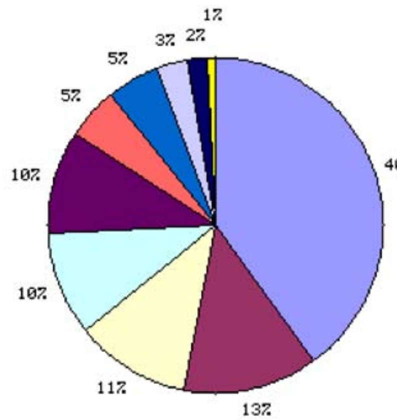


Figure 5: JTMDC Layout



Class Name	Average Rate (bps)	(%)
1. /Inbound/udp/8010_VSTAR_MTI	8511	40
2. /Inbound/udp/8040_HORIZON	2777	13
3. /Inbound/udp/SNMP	2463	11
4. /Inbound/udp/8053_FW_ASTOR_SAR	2138	10
5. /Inbound/udp/8090_GH_MTI	2094	10
6. /Inbound/udp/8050_ASTOR_MTI	1101	5
7. /Inbound/udp/1400_L16	1030	5
8. /Inbound/udp/8093_FW_GH_SAR	555	3
9. /Inbound/udp/8203_FW_U2_SAR	468	2
10. /Inbound/udp/Default	97	<1
All other classes	190	1

period: 10-hour, 26-Jun-2001 05:00 to 26-Jun-2001 15:00

Figure 6: 26th of June, 05:00-15:00, top users of bandwidth.

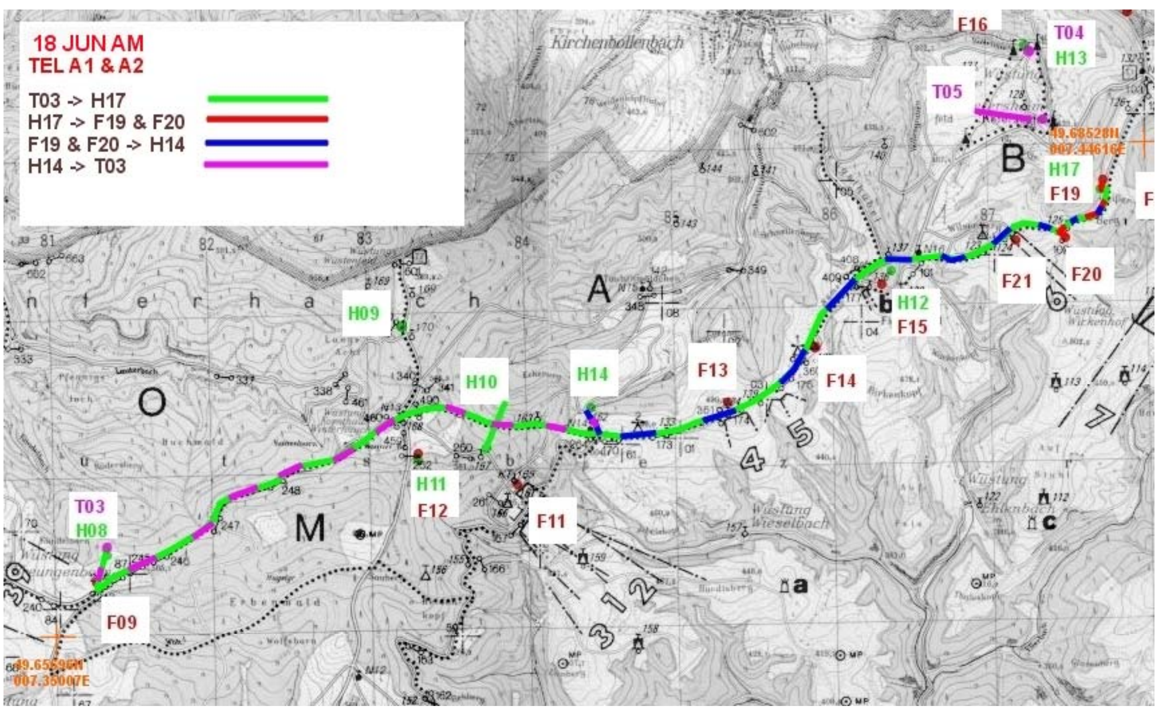


Figure 7: Example of Detailed Movement Plans for TEL units